should be adopted as final, and the difference as the initial error of the office standard.

In comparing the office standard with the 8 a. m. (seventy-fifth meridian time) readings given on the Daily Weather Map, it should be remembered that the latter have been reduced to standard gravity. *The reading of the office standard, if mercurial, must therefore also be so reduced before comparing.*

If a self-recording aneroid is employed care should be taken to see that the times indicated on the barograph are correct. At local noon of each day the box should be tapped with sufficient force to slightly disturb the index hand. The exact point on the curve corresponding to local noon will thus be recorded.

If the ship's barometer gives the atmospheric pressure in millimeters the readings of the standard should be converted to millimeters before entering upon the card, using for this purpose Table 4 of the "Barometer Correction Card."

TABLE 1.—*Reduction of the barometer to sea level.*

Height.	Correction.
Feet.	*Inch.*
20	+0.02
......	......
140	0.14
160	0.17
......	......
300	0.31

TABLE 2.—*Reduction of the mercurial barometer to standard gravity (calculated for pressures between 29 and 31 inches).*

Latitude.	Correction.	Correction.
	Inch.	*Millimeters.*
0°	−0.08	−2.0
......	......	......
40	−0.01	−0.4
45	0.00	0.0
50	+0.01	+0.4
......	......	......
90	+0.08	+2.0

TABLE 3.—*Temperature correction (calculated for mercurial column of 29.50 inches).*

Attached thermometer.			Correction to be applied to reading.
Fahr.	Cent.	Réau.	
°	°	°	*Inch.*
5	−15.0	−12.0	
6	−14.4	−11.6	+.06
7	−13.9	−11.1	
......	......	......	......
27	−2.8	−2.2	
28	−2.2	−1.8	.00
29	−1.7	−1.3	
30	−1.1	−0.9	
......	......	......	......
95	35.0	28.0	
96	35.6	28.4	−.18
97	36.1	28.9	
98	36.7	29.3	

TABLE 4.—*Conversion of millimeters to inches.*

Mm.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
700	27.56	27.56	27.57	27.57	27.58	27.58	27.58	27.59	27.59	27.60
701	.60	.60	.61	.61	.61	.62	.62	.63	.63	.63
702	.64	.64	.65	.65	.65	.66	.66	.67	.67	.67
703	.68	.68	.69	.69	.69	.70	.70	.71	.71	.71
704	.72	.72	.72	.73	.73	.74	.74	.74	.75	.75
......	......	......	......	......	......	......	......	......	......	......
795	31.30	31.30	31.31	31.31	31.32	31.32	31.32	31.33	31.33	31.34
796	.34	.34	.35	.35	.35	.36	.36	.37	.37	.37
797	.38	.38	.39	.39	.39	.40	.40	.41	.41	.41
798	.42	.42	.43	.43	.43	.44	.44	.45	.45	.45
799	.46	.46	.47	.47	.47	.48	.48	.48	.49	.49

Especially do we note that the above instructions make full provision for a very important matter, viz, the determination of the initial error, or the error of zero point, or the general relation of the ship's barometer to the international standard adopted by the Weather Bureau and the Hydrographic Office.

When barometers are brought from vessels to the shore and hung alongside of a station instrument for comparative readings, it is usually found that the ship's barometer needs a correction in order to make it agree with the standard. Now a barometer is a comparatively delicate and complex instrument, and there is no assurance that this correction has not been changed or perhaps even wholly caused by some accident in bringing the instrument from the ship to the station; there is also no assurance that it will not again change when carried from the station back to the ship. It is, therefore, far better not to remove the barometer from its permanent place on shipboard. The correction that is desired can be just as well determined by simultaneous readings taken on the ship and at the land station of the Weather Bureau. The navigator has simply to reduce the ship's readings to standard temperature by Table 3, standard gravity by Table 2, and sea level by Table 1, and compare the result with the observations on land, or the isobars of the daily chart, which are also reduced to sea level, gravity, and temperature. The regular observations at 8 a. m. and 8 p. m., standard eastern time (which is the same as 1 p. m. and 1 a. m., Greenwich time), can be used for this purpose day after day. This is the method adopted and recommended by the Editor in 1871 for the voluntary marine work of the Signal Service, and continued when he took charge of the reduction and publication of the international simultaneous work in 1875. The Hydrographic Office very properly recommends that readings for comparative purposes should be made on at least three different days when the vessel is in port, but the Editor would hope that vessels may be able to maintain their record when in port as regularly as when at sea, so that there may be no breaks in the record.

It is highly important that all mariners should cooperate in this effort to attain the highest accuracy in their barometric observations. The little additional labor means a greater addition to meteorology. It is simply doing things in the right way instead of in a slipshod, wrong way.—*C. A.*

WHAT IS A STORM WAVE?

The following query was recently received by the Chief of the United States Weather Bureau:

The Standard Dictionary's definition of storm wave reads "A wave on the ocean surrounding a cyclonic area: caused by a difference in pressure." In the number for December, 1900, of Science and Industry, Mr. Ernest K. Roden published an article entitled "Revolving Storms." In this article he states that the storm wave is at the center of the storm area, and gives a sketch showing how it is formed. Would you be so kind as to favor us with your judgment as to the accuracy of these statements; which would you think is correct?

A board was appointed by the Chief of Bureau for the purpose of considering the definition of the term storm wave. The Chief also submitted to the board the following additional queries:

Does centrifugal force cause the water to be scooped out under the center of the cyclone, and to bank up in a ridge around its outer periphery; or does the decrease in air pressure, that is the result of centrifugal force, acting upon the water cause the water under the center of the cyclone to bulge up like an inverted soup plate?

A brief review of the literature on this subject will be of interest, not only on account of its bearing upon the significance of the term storm wave, but because it also gives us a full discussion of the meteorological conditions that produce this phenomenon.

In Piddington's Sailor's Hornbook, 1848, p. 127, we read:

Every seaman has also seen that under a waterspout the sea is boiling and foaming, and rising up, and traveling along with the spout, in a space of perhaps some two hundred yards or more in diameter, and he can suppose that, if a boat could live within it, it might be carried along as far as the waterspout traveled, which would then be also a miniature representation of what we suppose to take place in the case of the storm wave, which at present, for we want information greatly on this as on many other points, we suppose to be somewhat as follows:

As there is no doubt that the atmospheric pressure when diminished in any one particular point of the globe occasions a temporary rise of the waters under this point, which are pressed up by all the rest, and that at the center of cyclones a diminution of pressure, which varies from an inch to two and a half inches of mercury, occurs, so there is no doubt that at this particular part of the center the water is raised a little more than a foot for every inch of fall of the mercury, or about two feet in ordinary cyclones, and proportionably over the whole area of them. The incurving of the wind * * * must also have a tendency to keep up and support a mass of water at, and toward this part, and we assume that this mass of water, or at all events a body floating upon it, is born by the conjoined action of the wind and this wave, onward in the direction of the path of the storm. This is what we denominate the storm wave, and what I have quoted and said is the theory or theoretical description of it.

From The Progress of the Development of the Law of Storms and of the Variable Winds, 1849, p. 102, by Lieut. Col. Wm. Reid, we quote the following:

In a paper communicated to the Royal Society of Edinburgh by Mr. Milne, and published in their Transactions for 1839, he describes two whirlwind storms which passed over the British Islands, and he thus speaks of the storm wave:

The effects of this gale on the waters of the Atlantic caused an unusually high tide in almost all parts in the Irish and English channels. I find that on Wednesday night, the 28th of November, 1838, Newry, a town to the north of Dublin, was inundated by the highest tide remembered. It was also a remarkably high tide at Strangford and at Donaghadee. On the same night, at Swansea, the tide rose seven feet two inches above its proper level. * * *

At Oban and Tobermory, though these places are completely landlocked and exposed to no swell from the ocean, all loose materials lying on the quays were swept off by the mere rise of the tidal waters. The height of the tide was there the more remarkable, as it was the season not of spring, but of neap tide. That this extraordinary elevation of the sea was occasioned by the suddenly diminished pressure of the atmosphere there is no doubt. The effect of this diminished pressure must have been to elevate the surface of the ocean, and produce a sudden accumulation of waters, a species of wave.

The following is from the Laws of Storms, etc., 1850, p. 504, by the same author:

At the island of Ascension, as well as at St. Helena, there are no storms; but at both places a very heavy swell occasionally sets in which the inhabitants call "rollers."

These rollers are said to come from leeward, which is there the northwestward. There has been much speculation as to what can cause this sudden swell of the sea; some believing it to be owing to volcanic action, and others supposing it to be the ground swell occasioned by distant storms. It is said that the rollers not unfrequently continue for a whole day.

In the narrative of Mr. Williams (a missionary in the South Seas) a similar swell of the sea is described. Speaking of Tahiti, he says: "Mostly once, and frequently twice a year, a very heavy sea rolls over the reef, and bursts with great violence on the shore; but the most remarkable feature in the periodical high sea is that it invariably comes from the west or southwest, which is the opposite direction to that from which the trade wind blows. The eastern sides of these islands are, I believe, uninjured by these inundations."

When the swell, proceeding from a hurricane, rolls against the east side of an island within the Tropics, some part of the storm which causes it will usually pass over that island, but a distant storm may pass on either side, sending only its swell upon the shore.

Mr. F. P. B. Martin, in The Rotary Theory of Storms, 1852, cites an instance of a swell from the west being experienced by a ship far to the south of the center of a storm. As the latter passed eastward the direction of the swell was from the northwest, thereby indicating the direction in which the storm was moving. On page 148 he states that—

The rollers at Ascension and St. Helena, which are stated "to come from leeward," that is to the northwestward, would possibly be formed by the rear right-hand quadrant of a cyclone formed to the westward of those islands, and traveling away from them toward the coast of South America.

Rear Admiral Fitz Roy, in the Weather Book, 1863, pp. 386–387, alludes to the fact that at the Mauritius and in the River Plata, the water usually rises before a storm, while at the same time the barometer is falling.

In the wide but shallow Plata the depth of water and nature of current vary in remarkable accordance with the barometric changes.

Another cause of the water rising before a high wind, or storm, as well as of a ground swell, of rollers, or that of disturbed tumultuous heaving of the sea, sometimes observed while there is little or no wind at a place, is the action of wind on a remote part of that sea; an action or pressure which is rapidly transmitted through a nonelastic fluid to regions at a distance.

In his Handy Book of Meteorology, 1868, p. 267, Mr. A. Buchan, says:

Storm wave of the sea accompanying the hurricane.—Owing to the diminished pressure of the air at the center as compared with what prevails at the outskirts of the storm, the difference being fully two inches of mercury, the level of the sea at the center would be raised about three feet, being sustained at that height by the greater pressure all round. This increase of level, when occurring at high tide, and being increased still further by violent winds blowing in upon the center, quite accounts for the advances made by the sea over the land, especially over the low lying islands, and the heartrending scenes of desolation which it causes.

The storm wave, then, is the destructive wave due to the combined action of the wind, the high tide, and the diminished pressure, or gradient of pressure. Buchan says that in October, 1864, the storm wave at Calcutta rose ten feet above the highest spring tides.

In The Indian Meteorologist's Vade Mecum, 1876, p. 159, Mr. Henry F. Blanford gives the following graphic description of a storm wave and its effects:

The storm wave.—Great as is the destruction of life and property, both on sea and land, wrought by the blast of the hurricane, all such disasters as shipwrecks and homesteads devastated by the wind are utterly overshadowed and eclipsed by the fell sweep of the storm wave. It is probable that every cyclone is accompanied by a storm wave. The reduction of atmospheric pressure at the center of the storm, amounting sometimes to two barometric inches, would of necessity cause a rise of the mean level of the sea, amounting to about 13 inches for each barometric inch of diminished pressure; and, in addition to this, the winds, in virtue of their friction on the sea surface, and the spiral incurvature of their course, must tend to pile up a head of water in the central part of the vortex. But it is only when the wave thus formed reaches a low coast, with a shallow shelving foreshore, such as are the coasts of Bengal and Orissa, that, like the tidal wave, it is retarded and piled up to a height which enables it to inundate the flats of the maritime belt, over which it sweeps with an irresistable onset. As might have been anticipated, the destructiveness in each case depends very much on the phase of the tide at the time of the storm wave's approach, and also on the phase of the moon; since if a storm wave arrives at the time of flood during the height of the spring tides, the effects are cumulative, and the depth of the inundation and the extent of the destruction so much the greater. But if it arrives at the time of low water in the springs, its effects may be to some extent neutralized. Its full effects are most felt on the right of the central track of the cyclone, for the direction of the wind there coincides with the advance of the wave; whereas on the left of the track the wind generally opposes its advance. But the acme of its destructive power is displayed where a broad, shallow river estuary stretches up into the land to the right of the storm track—estuaries, for instance, such as the Hooghly and the Megna, in which the tidal wave is ordinarily heaped up and retarded, forming a *bore*. Under such circumstances, the flats around these estuaries have become the theater of the greatest natural catastrophes recorded in history; for as such they may be estimated, even after due allowance has been made for the imperfection of Indian statistics, and the irresistible tendency of the unscientific mind to exaggerate all great disasters.

Mention has already been made of the storm of the 7th of October, 1737, in which the storm wave is said to have risen to 40 feet in the Hooghly, sweeping away 300,000 souls. In May, 1787, at Coringa, near the mouth of the Godavery, a storm wave is said to have swept away 20,000 souls; and the storm of the 31st of October, 1831, which passed between Balasore and Cuttack, was accompanied by an inundation which destroyed 300 villages and 11,000 people. In the Calcutta cyclone of the 5th of October 1864, the storm wave inundated the flats on both sides of the Hooghly estuary, causing a loss of life, which a subsequent census (in part an estimate only) put at about 48,000 souls and considerably upwards of 100,000 cattle. The height of the storm wave at Cowcolly Lighthouse was 16.48 feet above the level of high spring tides and this was about its greatest rise. At Kidgeree it was 15.9 feet, at the mouth of the Huldi River 10 feet, at Diamond Harbor 11.9 feet, and at the junction of the Roopnarain and Hooghly also 11.9 feet above high spring tide level. The resulting inundation had a depth of from 15 feet downward, over the land surface, and over a tract from 4 to 10 miles broad, extending from the banks of the river inland; the destruction was extreme.

But even this great disaster was eclipsed by that of Backerganj on the night of the 31st of October and 1st of November, 1876. This was not the first catastrophe of the kind that has ravaged this part of Bengal, even since the beginning of the century. In June, 1822, the flat rice lands about the mouth of the Megna were submerged by a storm wave, and 50,000 souls are said to have perished. But the loss in the recent cyclone was far heavier, and, notwithstanding the great reduction subsequently made on the original estimates of the loss of life (a process which has never been carried out with those of the earlier cyclones), it may probably still rank as one of the most destructive natural catastrophes on record.

In the Indian Meteorological Memoirs, Report of the Vizagapatam cyclone, October, 1876, p. 51, and especially p. 158, Mr. John Eliot attributes storm waves to much the same causes as does Blanford. So, also, does R. H. Scott in his Elementary Meteorology, 1882, p. 375, and likewise Robert deC. Ward in the American Meteorological Journal, 1892, p. 269.

Blanford, Eliot, Scott, and Ward had especially in mind the storm waves that accompany the cyclones of the Indian Ocean.

In the American Meteorological Journal, 1894, p. 498, in an article on "Storms of the Gulf of Mexico and their prediction," Mr. Wilfred D. Sterns, principal of the Rosenberg School, Galveston, Texas, writes as follows:

(1) Twelve hours or more before any other indication of the storm's approach the surf at this point increases in intensity. The sea continues rough until the storm center has passed far to the eastward. Instead of a simple undulation, two distinct wave motions, making an angle with each other of about 60°, may be noted. This system swings as a whole toward the east with the passage of the disturbance in that direction. (2) A great increase in wave length is early noticeable. (3) A marked and quite sudden rise in the tide occurs without wind or a sufficient increase in a favorable wind to account for it. This increase is entirely distinct from the gradual piling up of the water which takes place under the influence of a gentle but constant southeast wind, although a steady wind may produce ultimately an even higher tide.

In the MONTHLY WEATHER REVIEW for May, 1896, p. 154, in an article on "The destructive force of hurricanes and the conditions of safety and danger," Gen. E. P. Alexander writes as follows:

When a hurricane passes inland it soon becomes little more than a bit of very bad weather. Its great instrument of destruction is the so-called tidal wave or storm tide, or more properly, storm wave, which is raised by it, and which submerges the lowlands of the coast. Below the limit to which these waves rise is the zone of danger in a hurricane; above it is the zone of easily attained safety.

How far this danger line may extend above ordinary high water depends so largely upon local configuration of coasts that it is only to be determined for any locality by observation. Unfortunately, reliable measurements and data upon this point are rare and difficult to obtain. Popular accounts are always exaggerated, being largely based upon the action of surface billows, which send water and drift far above the general level of the storm wave. A vessel, for instance, drawing 8 feet, may be carried by successive billows across a marsh submerged only 4 feet below the general level. I have read accounts of combined storm waves and high tides rising 10 or 12 feet above ordinary high water mark, but when the action of billows is eliminated and careful measurements are made, the highest record of a storm tide above ordinary high water which I have been able to find anywhere is 8.2 feet. This limit was reached at Fort Pulaski, Ga., in the great gale of August 27, 1893, which broke all records in the height of its waters, in the destruction of life and property, and in the measured velocity of its winds, which at Charleston, S. C., for a few moments, exceeded 120 miles per hour. As this gale is one of great interest, the reader is referred to the records published in the MONTHLY WEATHER REVIEW for October, 1893, p. 297. The center of the hurricane passed directly over Savannah, Ga., and it will be seen that there the barometer fell lowest and the storm tide rose highest, the wind falling to a dead calm for twenty minutes as the center passed, after which it rose from the opposite quarter. The center passed about 80 miles west of Charleston.

Finally, Ernest K. Roden in his article of December, 1900, above referred to, writes as follows:

So much for the danger arising from the great velocity of the wind and the heavy sea produced by such wind. But wind is not the only destructive element accompanying a cyclone. Another danger is the storm wave that, so to speak, follows the wake of the storm center and at times completes the work of destruction.

The storm wave is of no particular importance to ships that have plenty of sea room; it is the coast cities and fishing communities situated on lowland that will feel its effect when struck by a hurricane advancing from offshore. This was particularly the case at Galveston, Tex. The wind alone would never have caused such loss of life; it might have wrecked a great many less substantially constructed buildings and thereby caused the death of a considerable number of the inhabitants, through their inability to escape from the strange fate of being buried in the ruins of their own homes, but such high figures as are now written on the death list of Galveston would never have been reached by the agency of the wind alone. It was that dangerous ally of the wind, the storm wave, that ran these figures up so high.

By "storm wave" we mean the wave raised by the wind and the atmospheric condition of the hurricane, which by many is erroneously termed the "tidal wave." It should be understood, however, that the storm wave has necessarily no connection with the phenomenon of tides, although it may under certain circumstances, be affected by it. How this storm wave, which hitherto has been given but slight attention, except for its effect, is produced, may possibly prove of interest. It is a fact well known to students of tides and tidal phenomena in general that the atmospheric pressure has a marked effect on the height of tides. When the barometer is low the tides become higher than under normal atmospheric conditions; in other words, a low barometer, or what is the same thing, a less pressure, will produce a higher tide. Applying this theory to cyclones, the cause of the storm wave is readily understood. As previously stated, the atmospheric pressure at the storm center is considerably less than outside of the storm area; consequently, the equilibrium of the water being disturbed by unequal pressure it will be heaped together and rise at the place of least pressure, which is at the center of the hurricane.

The board above referred to formulated the following report:

The board finds no necessity for giving a new meaning or a specific definition to the term "storm wave." Like most other words in the English language it has been used for many years and with a great variety of meanings, each of which has good authority. It would be a work of supererogation for us to attempt to restrict its use to any of these meanings. Indeed, we believe that the compiler of a dictionary of the English language will naturally desire to include all these meanings, and, therefore, we give them in detail as follows:

1. Old nautical usage. The old sailor's term for a heavy wave without a severe wind and evidently due to a storm not far distant. (See Admiral Belcher's Nautical Dictionary of 1867.)

2. Old usage along the Atlantic coast of North America. A long, gentle swell or ground swell felt at any point on the Atlantic coast and which is considered by local seamen to indicate the presence of a hurricane far away to the south or southeast but advancing up the coast. This storm wave or hurricane swell was formerly used in local forecasts by the navigators. It was explained by Redfield about 1833, and is the same as the swell referred to by Reid in 1849 and 1850, and by F. P. B. Martin in 1852.

3. A destructive wave or bore due to the combined effect of high tide and heavy gale sometimes occurring within the dangerous quadrant of a hurricane. (See Reid, 1849.)

4. A theoretical rise or bulging up of the water within the oval region of a very low barometric pressure and due to the greater pressure on the surrounding region of high barometer. This was argued for by Piddington, 1848, and Fitz Roy, 1863, and Buchan, 1868, but has not as yet been actually observed by any one and is in general not separable from the rise due to wind and tide.

5. A destructive wave, overflowing land and buildings and undoubtedly due to the combined effect of strong winds, high tide, and low pressure in a region where the coast lines converge and the water shoals rather rapidly. This is the general usage of to-day, and was adopted by Wilson, 1875, Blanford, 1876, Eliot, 1876, and the Weather Bureau generally as exemplified in the MONTHLY WEATHER REVIEW, 1900, p. 154.

6. This term is not usually confined to the rise of water due to the mere decrease of pressure within a low area as was done by Roden in his article of 1900.

The motion of the surface water within a cyclone is so slow that its contrifugal force will not produce anything more than the slightest and inappreciable scooping out of the water at the center, and no appreciable banking up in a ridge around the periphery.

Again, the diminished atmospheric pressure near the center of a cyclone should allow the ocean water to bulge up or rise to the extent of about one foot for each inch of barometric depression, provided the cyclone stands in one place long enough to allow this pressure to produce its full effect; ordinarily storms move so rapidly that only a small proportionate rise of the water can be thus produced.

No observations have been made or seem to be practicable for determining the actual rise of water within a hurricane on the open ocean. The rise observed at seaports when a hurricane passes near is due principally to the wind and tide, of which an example is given in the diagram exhibited by Gen. E. P. Alexander in the Monthly Weather Review for May, 1896, who uses the term "tidal wave" or "storm tide" or "storm wave" as representing the total effect of the storm on the water, and, therefore, quite in accord with our definition No. 5.

It is earnestly to be desired that observers learn to distinguish between tidal waves and storm waves. Blanford describes a typical tidal wave under the name of *bore*. (See page 461.)

As has already been pointed out,[1] most of the so-called tidal waves are really storm waves.

Severe waves often accompany earthquakes, as was the case in Lisbon in 1755 and in Japan in 1895; these are not tidal waves, but may be called *earthquake waves*.—*H. H. K.*

ON BAROMETRIC OSCILLATIONS DURING THUNDERSTORMS, AND ON THE BRONTOMETER, AN INSTRUMENT DESIGNED TO FACILITATE THEIR STUDY.[2]

By G. J. Symons, F. R. S.

[Reprinted from the Proceedings of the Royal Society, vol. 48, 1890.]

The fact that a rise of the barometer occurs during thunderstorms has been supposed by many to be newly discovered through the general establishment of self-recording barometers; but Dr. Hellmann has shown that it was noticed by J. J. Planer as far back as 1782. In 1784, Rosenthal epitomised the facts as follows: "When a thunderstorm approaches the place where a barometer is situated, the mercury in the tube begins to rise; the nearer the thunder cloud comes to the zenith of the observer, the higher does the mercury rise, and it reaches its highest point when the storm is at the least distance from the observer. As soon, however, as the cloud has passed the zenith, or has become more distant from the observer, the weight of the atmosphere begins to decrease and the mercury to fall." A few years later, Toaldo determined the amount of the rise in several storms, and found it to be between 1 and 2 lines (0.09 inch to 0.18 inch).

Professor Strehlke (in 1827–1830) made several sets of observations, and found the rise to be from 0.04 inch to 0.06 inch, and was probably the first to point out that the highest point of the barometer is not absolutely synchronous with the passage of the center of the storm-cloud, but seems rather to be always at a certain distance from it.

Kaemtz, in his Lehrbuch (1832), suggests that the rise is produced by the inrush of air toward the site of the storm, this accumulation causing the rise of the barometer as the storm nears the zenith.

Although Luke Howard had a recording barometer at work in the early part of this century, he seems to have failed to notice the phenomenon; and no one in England seems to have been aware of it until the photographic barometer was started at the Radcliffe Observatory, Oxford. Manuel Johnson, when describing the new instruments at the British Association meeting at Glascow, in 1855, said:—

"Among the most remarkable results is a sudden rise of the barometer, amounting to 0.035 inch, and an increase of temperature of 1°, coincident with the occurrence of a thunder clap which struck one of the churches in Oxford, July 14, 1855. A similar phenomenon took place during a thunderstorm on August 23, when the rise of the barometer was still greater, amounting to 0.049 inch, though the thunder clap coincident with this rise was distant."

[1] See Monthly Weather Review for 1900, Vol. XXVIII, p. 154.

[2] The article on thunderstorms in the Monthly Weather Review for July, 1901, discusses some questions that deeply interested the late G. J. Symons, founder of the splendid system of British rainfall stations and editor of Symons' Meteorological Magazine. His successor, H. Sowerby Wallis, kindly sends us a special copy of the paper by Mr. Symons which we now reprint as it is undoubtedly but little known to our American observers, some of whom have been "discovering" facts that were known a hundred years ago. A complete review of our knowledge of thunderstorms as it stood in 1893 will be published in the last part of the Proceedings of the Meteorological Congress of Chicago. Meanwhile this memoir of Symons is exceedingly suggestive. The brontometer described therein is still in working order in London and can be purchased for $500. If several of them could be established within 5 miles of each other they would give many of the observational data that are needed by those who wish to investigate the exact phenomena of thunderstorms, hailstorms and tornadoes. We commend it to those sections in which destruction by lightning and hail and wind is sufficient to stimulate the special study of local storms with a view to prediction and protection.—*C. A.*

Mr. Johnson returned to the subject in the volume of Radcliffe Observations for 1857, and gave reproductions of fourteen barograms, but the scale is so compressed (only ½ inch per hour, and 1¼ per inch of mercury) that not much is to be learned from them beyond the fact that falls occur of 0.037 inch, 0.040 inch, and 0.046 inch, and a rise of 0.070 inch; the notes on the storms are also too vague to be useful. It may, however, be well to quote the conclusion at which Mr. Johnson arrived, viz.:—

"A comparison of these notes with the accompanying illustrations cannot, in my opinion, fail to lead to the inference that the disturbances exhibited both on the barometric and the thermometric curves (especially the former) are caused by the presence of electricity in the atmosphere, of which we had on these occasions sensible proof. But they are the more interesting, from the circumstance that similar disturbances occur not unfrequently when there has been no overt manifestation of that agency; especially during the winter months, when, according to the concurrent testimony of all observers, atmospheric electricity is most abundant."

The next observation of importance is one quoted by Le Verrier, as reported to him by the observer, M. Goullon, Curé of Saint-Ruffine (Moselle). He had two barometers, a mercurial and an aneroid. On the morning of February 5, 1866, the weather being stormy with heavy rain, wind southwest, moderate, but not squally, he had just set and read his barometers, when there was a solitary loud clap of thunder, and instantly both his barometers rose 2 millimeters (0.08 inch).

The Hon. Ralph Abercromby began studying these oscillations in 1868, and in 1875 summed up the results in the following sentences, one descriptive, the other explanatory:—

"There are two classes of storms in this country: in the one the barometer rises, in the other it falls. In the case in which it rises, the sequence of weather is somewhat as follows: After the sky has become overcast, the wind hushed to an ominous silence, and the clouds seem to have lost their motion, the barometer begins to rise suddenly. In the middle of this rise, sudden heavy rain begins. After a few minutes the rain, with or without thunder and wind, becomes a little less heavy, and the barometer sometimes falls a little. The rain then continues till the end of the squall, and as it stops the barometer returns to its original level. In Great Britain the rise rarely exceeds 0.10 inch, or lasts more than two hours. These rises are always superadded to a more general rise or fall of the barometer, due either to a cyclone or to one of the small secondaries which are formed on the side of one. During some rises the wind remains unchanged; with others there is a more or less complete rotation of the wind. In all cases the disturbance seems to be confined to the lower strata of the atmosphere." * * * "Since the rise is always under the visible storm, it is propagated at the same rate and in the same manner as the thunderstorm. Enough is known of the course of the latter for it to be certain that they are not propagated like waves or ripples, and hence these small barometric rises are not due to aerial waves, as has been suggested. Since their general character is the same whether there is thunder or not, it is evident that electricity, even of that intensity which is discharged disruptively, is not the cause of the rise. If we look at a squall from a distance, we always see cumulus above it, which is harder or more intense in the front than in the rear of the squall. Since cumulus is the condensed summit of an ascensional column of air, it is evident that the barometric rise takes place under an uptake of air. If we consider further that a light ascensional current would give rise simply to an overcast sky, a stronger one to rain, while a still more violent one would project the air suddenly into a region so cold and dry that the resulting electricity would be discharged disruptively as lightning, the foregoing observations show that the ***greatest rise is under the greatest uptake.*** Our knowledge of the mechanics of fluid motion is still too unsettled for us to say with certainty whether or not an ascensional current of air would have a reaction backward, like a jet of air issuing from an orifice."

Professor Mascart also, in 1879, expressed the opinion that electricity had nothing to do with these oscillations, but suggested quite a different explanation. Premising that they are not produced by all heavy rains, but only when heavy showers fall during bright weather, he suggested that at such times rain falls through nonsaturated air, where it would evaporate freely, and so produce a local increase of pressure which, in certain thunder rains, might amount to 2 millimeters (0.08 inch). He explained the diminution of pressure which sometimes occurs, by the reversed phenomenon; he considered that thunderstorms are formed locally, and suggested that the condensation of masses of vapor into rain drops ought to produce a diminution of pressure.

M. Teisserenc de Bort and Mr. Budd have suggested that the rise may be due to the local compression of the air by the multitude of falling rain drops.

In the Annales of the French Meteorological Office for 1880, M. Renou gives reproductions of some barograms from the Observatory at Parc St.-Maur. A very interesting one is reproduced in fig. 1. M. Renou does not append any remarks to the plate; but from other sources it appears that there was a heavy thunderstorm from 10 till 11 p. m. on August 18, 1878. The total rise may be taken as 0.10 inch and the fall as nearly 0.15 inch.